Using an AR Simulation for Hospital Spill Cleanup Training in Highly-Infectious Disease Holding Units

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Abstract

This project explores the implementation of an augmented reality training simulation in a hospital cleanup environment. Specifically, the simulation teaches cleanup staff to correctly sanitize surfaces containing contaminated spills in isolation units of highly infectious disease wards. We are using Microsoft's HoloLens, a head-mounted display unit that uses a pair of mixed reality smartglasses. We are making the simulation as immersive as possible, implementing recorded audio from hospital machinery and video of a distressed patient and nurse. We are presenting the cleanup process in steps with which the user will follow along. A talking head-style virtual instructor communicates each step to the user before they begin to complete it. By developing the simulation as a realistic recreation, we intend to better prepare cleanup staff for if/when they have to complete the task in the event of an actual contagion situation.

Introduction

Studies regarding contamination in hospital and lab settings have focused heavily on the disinfecting products, and which product most effectively sterilizes infected surfaces (French, 2004, Wilcox, 2003, Wedowski, 2006). In clinical environments exposed to highly infectious diseases, proper cleaning techniques are essential to preventing the spread of contagion. In hospital holding units for patients with new highly infectious diseases (take, for instance, the unprecedented outbreak of the Ebola virus), cleaning staff must be taught decontamination practices that address these new threats. Efficient teaching programs, however, are often not at the forefront of these areas of research (Youkee, 2015). As a result, clean-up specialists have generally overlooked modern teaching strategies that can more productively keep hospital

cleaning staff up-to-date. In particular, augmented reality can be used as an educational tool in this context as it has been used in many others.

The emergence of augmented reality (AR) technology has allowed researchers to explore new applications of virtual environments (Cai, 2014, Alaraj, 2013). Specifically, researchers have been finding that AR training simulations, when compared to other training methods (2D interactive simulations, textbooks, etc.), significantly improve learning patterns and skills in users. In middle school classrooms, AR simulations have been used to help students visualize chemical microstructures (Cai, 2014). In operating rooms, they have been used to simulate neurosurgical procedures in extensive detail (Alaraj, 2013). We are developing an AR training simulation to guide hospital cleaning staff through decontamination protocol for these dangerous contamination spills. The simulation is an immersive imitation of a real contagion scenario and includes even the high-stress aspects (multiple spills, a loud, distressed patient, loud machinery, etc.). We are working with the highly infectious disease holding unit at Emory hospital. The purpose of developing and employing the AR system is to train hospital staff quickly and to optimize learning retention so that cleanup failures, in the event of sudden contagion, are minimized.

Methods

Participants

To obtain user feedback on the simulation, we are using nurses from Emory hospital who have volunteered to use the system. We are specifically looking for

feedback on the clarity of instructions, the interactions with the virtual environment, the presence of sound cues and background noise, and overall user experience.

Materials

We are building the project in Unity 3D with Microsoft's HoloLens. The simulation will be used in the actual isolation units at Emory Hospital. To record video and audio footage, we used a green screen, cameras, microphones, and film lights.

Procedure

We first built a prototype simulation with place-holder audio and video obtained from online asset stores and early film footage. We created a scene in which the user can use HoloLens gestures to interact with a simulated spill on the hospital floor. We then added the virtual instructor, who presents the cleanup instructions in a series of steps. We added buttons that allow the user to hear the current or previous steps again. We then created a main menu from which the user can adjust audio settings.

We traveled to Emory Hospital to record audio and visual footage. Video was filmed in front of a green screen to isolate the subjects we include in the simulation. For audio, we recorded the heart monitor machine, the IV machine, the PPE (personal protective equipment) head fan, and the ambient music. Later, we edited the audio so that it could be looped smoothly when implemented. We will soon implement the audio and video.

Literature Review

Methods of sterilization often depend on the way the specific virus or bacteria is spread (6). Some viruses or bacteria can be easily spread through contact with

contaminated surfaces. Others are spread through bodily fluids. Hospital cleaning procedures for newly introduced infectious diseases must be updated to prevent the spread of contagion. After the outbreak of the Ebola virus, for example, hospitals' staff had to be retrained to account for the unique severe threats the virus posed (1). Increasingly often, however, hospitals' clean-up staff have demonstrated lapses in performing cleaning procedures properly, despite the existence of nationally-guided institutional policies (2). This would suggest that members of cleaning staff themselves were not retrained in a successful way, and that, considering the importance of proper cleaning in stopping diseases from spreading, hospitals and patients would benefit from better teaching practices. When compared to others, the benefits of augmented reality (AR) training simulations make it a teaching practice worth implementing.

Augmented reality differs from virtual reality (VR) in that it overlays elements of a virtual world onto the user's actual physical environment. Users are able to interact with these virtual elements, which makes AR a much more natural human-technology interaction experience. In the context of an AR training simulation, the virtual elements within an AR program (which includes things like computer-generated visual objects, videos, and audio) can simulate objects or phenomena that would be present in the actual physical environment, but are difficult or dangerous to replicate (3). Visualizations of chemical microstructures, for instance, would be impossible to interact with without AR technology. For middle school students in a typical chemistry course, teaching concepts that deal with these microstructures is continually challenging (3). Young students lack the comprehension skills necessary to understand that which they cannot physically see; thus, the beginning stages of chemistry learning often lead to

misunderstandings of foundational concepts. With the implementation of an inquiry-based AR program in a 2014 case study, however, students could control, combine, and interact with 3D chemical microstructures and perform their own experiments. The researchers declared that the AR tool had a significant learning effect, especially for lower-achieving students, and that the students had generally positive attitudes towards the software (3).

AR training simulations have also been useful in medical contexts. ImmersiveTouch, an AR simulation program, allows medical students to develop their surgical skills without any of the usual risks of physical harm or death for the subjects on whom the students are operating. The simulation includes multiple sensory modalities, meaning that the virtual environment consisted of accurate replications of different types of sensations that would exist in the real environment -- sound cues (auditory sensations), haptic feedback (physical sensations), and visualizations (4). This creates realistic imitations of actual surgical procedures, lending itself to AR's ability to adequately simulate practices that can otherwise be physically dangerous. Additionally, students using the AR simulator significantly improved their skills, performing successful operations on live subjects after completing the training (7).

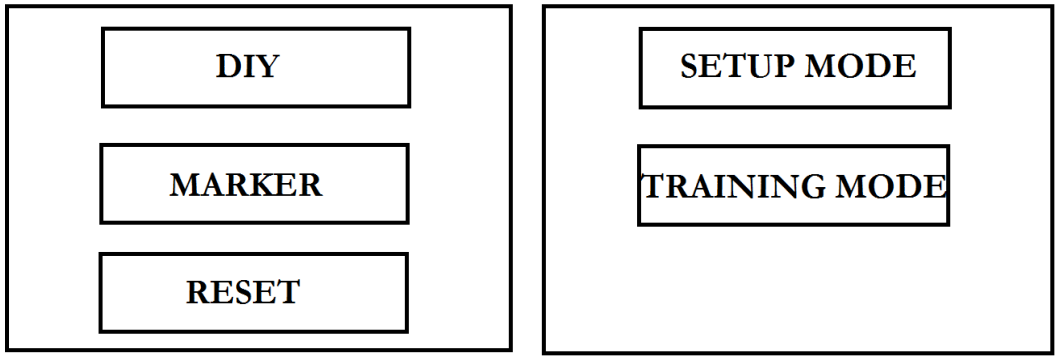
Another study focusing on augmented reality as a training tool found it to outperform traditional virtual simulation programs (5). Specifically, subjects using the AR system displayed more learning achievements than those who used the traditional simulation.

Because AR simulations can be applied when certain environments are too difficult or dangerous to recreate, and because the technology has been shown to

improve learning outcomes, we are using an AR simulation to train the hospital staff in Emory's highly infectious disease unit to clean up contamination spills.

System Walkthrough

The typical user of the simulation will be a hospital cleanup staff member who will be expected to clean infected spills and messes in isolation units. They will perform their training in the actual hospital holding unit that they would be working in in an actual spill scenario. The user will wear their PPE (Personal Protective Equipment) but will wear the Hololens instead of their usual head cover. They will be shown two menus:



Menu 1 Menu 2

Menu 1 follows the user's gaze, and menu 2 is in a fixed position in the environment. Selecting "setup mode" in menu 2 will allow the user to interact with menu 1. Selecting "DIY" will trigger a dropdown of selections of elements to be included in the training simulation. Options include the noisy patient, the nurse, the spill, and whichever step in the instructions the user elects to start from. As the user makes these selections, the objects appear in the scene. The user can tap and drag objects to arrange them however they'd like. Tapping "reset" removes the most recently added object to the

scene. Once the user is satisfied with the scene, they will tap “DIY” to close the dropdown list, and they can simply look back at menu 2 and select “Training Mode.” This will activate the scene they’ve selected. The video objects (the nurse, patient, and/or the virtual instructor) will play. The spill will be circled by a bright blue outline. The user can tap to pause the videos and then look back at menu 2 to reselect setup mode if they need to adjust the elements in the scene. They also have the option of moving to either the previous or next step in the cleanup process, or they can replay the current instruction.

Audio Handling

To create an immersive simulation, it’s helpful to include realistic audio. That is why we recorded audio from the actual machines used in Emory hospital. One of our environmental sounds, a song that plays on every television in the hospital, was used simply because the nurses who worked with us told us that everyone who worked in the hospital was sick of hearing it.

This simulation was built in Unity, which allows users to program an event system that listens for and then triggers different events in a scene. We handle our audio with this feature – the event listeners listen for when the user exits “setup mode” and enters “training mode,” and then trigger the events that play the audio clips. We also have some audio clips that play randomly; these clips are also handled by events that listen for “training mode,” and are then played randomly.

Conclusion

The conditions of a spill cleanup during a serious disease outbreak are both difficult and dangerous to replicate. The environment of the real-life scenario would contain a violently ill and possibly emotionally-frantic patient, a nurse dressed in full PPE (Personal Protective Equipment), loud machinery, intercom announcements, and biohazardous spills. We are using AR to recreate these elements with auditory and visual cues. Currently, training staff use oatmeal as substitutes for the spills, and don't simulate any of the other conditions. As mentioned, the current methods of training are resulting in cleanup failures. With developing realistic and accurate simulations of the cleanup environment, as with the previous applications of AR simulations, success rates for decontaminating soiled surfaces will likely improve.

Future Work

As of right now, a lot of this project is incomplete. We have to implement the rest of the sound effects, and conduct user testing on both the system itself and the implementation of the audio. Also, a lot of the technical functionality isn't quite there yet either, so that's something we aim to complete soon.

Work Cited

1. Youkee, Daniel, et al. (2015) Assessment of environmental contamination and environmental decontamination practices within an Ebola holding unit, Freetown, Sierra Leone. *PloS one* 10.12: e0145167.
2. Carling, P., & Huang, S. (2013). Improving Healthcare Environmental Cleaning and Disinfection Current and Evolving Issues. *Infection Control & Hospital Epidemiology, 34*(5), 507-513. doi:10.1086/670222
3. Cai, S., Wang, X., & Chiang, F. K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior*, *37*, 31-40.
4. Alaraj, A., Charbel, F. T., Birk, D., Tobin, M., Luciano, C., Banerjee, P. P., ... & Roitberg, B. (2013). Role of cranial and spinal virtual and augmented reality simulation using immersive touch modules in neurosurgical training. *Neurosurgery*, *72*(suppl_1), A115-A123.
5. Lin, T. J., Duh, H. B. L., Li, N., Wang, H. Y., & Tsai, C. C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. *Computers & Education*, *68*, 314-321.
6. Davis, Charles Patrick. Swine Flu (H1N1, H3N2v) Causes, Treatment, Symptoms & Vaccines. *EMedicineHealth.*
7. Yudkowsky, R. (2013). Practice on an Augmented Reality/Haptic Simulator and... : Simulation in Healthcare. *LWW*, Oxford University Press, 2013,